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FROM SPACECRAFT TO SPACECRAFT

Our correspondent met with a specialist in the field of aviation and space /30* medicine, Candidate of Medical Sciences, L. Golovkin, and asked him to explain the difficulties in transferring cosmonauts from spacecraft to spacecraft when the spacecraft has different atmospheres with respect to composition and pressure. Notes on this meeting are brought to the reader's attention.

The difference in atmospheres aboard the Soyuz and Apollo spacecraft (in the Soyuz it is almost like terrestrial atmosphere and contains about 20-30% oxygen and 70-80% nitrogen at a pressure of 760 mm Hg, while aboard the Apollo it is pure oxygen at a pressure of 260 mm Hg) has required inclusion in the space complex of a special system designed not only for mounting a new type of docking mechanism, but also for creating a docking chamber between the spacecraft.

What is the docking mechanism? It is a cylinder about 3 meters long and about 1.5 meters in diameter. Its internal volume is 3.65 m³. Two cosmonauts can be in the locking chamber of the mechanism simultaneously. Oxygen and the oxygen and nitrogen mixture are placed outside in two tanks. The locking chamber is equipped with an intercom device, sensors, the necessary control apparatus and equipment for supplying oxygen. Two space suits are stored in containers of the mechanism -- in case of any unforeseen event.

How will the cosmonauts transfer from spacecraft to spacecraft?

According to the expected program, our cosmonauts will first be visited by the Americans. In the first days, during docking of the spacecraft, two crew members of the Apollo will go to the Soyuz, and after several hours of visiting will return to their own spacecraft.

The reciprocal visit will take place the next day. This time a Soviet cosmonaut will become the guest of the American astronauts.

*Numbers in the margin indicate pagination in the foreign text.

In January, 1969, Soviet cosmonauts moved from ship to ship by another method -- through open space: A. Yeliseyev and Ye. Khrunov, having donned space suits with automatic life support systems, and using the orbital compartments of the Soyuz-4 and Soyuz-5 spacecraft as locking chambers, carried out a complex space experiment. These cosmonauts made their launch toward one spacecraft and their landing in another.

This is how the tasks have been solved which were related to ensuring safety of manned space flights and the use of orbital stations. But each country did this independently, with the use of its own equipment and its own technical ideas.

In the upcoming Soviet-American space experiment, at the initial stage of its discussion, the transfer of cosmonauts from ship to ship through open space was also visualized (in the framework of an emergency). This is in case any malfunctions appear in the docking assembly: if success is not attained, for example, in opening the transfer lock in the docking assembly. Now, however, according to press reports, such a transfer is not planned. The investigations which were conducted showed that the probability of appearance of obstacles for the return of the cosmonauts through the docking assembly is very small. One can eliminate practically all causes of mechanical malfunctions in this assembly. In case of breakdown of the automatic system, the cosmonauts will be equipped with instruments for working with the lock mechanism manually.

Now one should imagine that the spacecraft are already in orbit, that they have docked, and that the time has come for the American astronauts to transfer to the Soyuz.

As you recall, in the Apollo oxygen is under a pressure of 0.35 atmospheres, however, it will be increased somewhat; while aboard the Soyuz, the "terrestrial" atmosphere will be altered: pressure will lower to 0.7 atmospheres while the oxygen content will increase to 40%. This will be done in order maximally to approximate the parameters of the spacecraft's atmosphere.

It has been established that the transfer of man from an atmosphere at lower pressure to an atmosphere at greater pressure does not cause noticeable complications with moderate rates of pressure change.

Divers submerge to a great depth, but breathe air which is being supplied under high pressure during this process. True, one cannot increase the pressure infinitely: at a certain stage so-called nitrogen narcosis ensues, or, simply speaking, poisoning with nitrogen which comprises 79% of ordinary air. Therefore, in order to increase the depth of submersion, it must be replaced by any neutral gas, for example helium.

Unfavorable consequences for man begin when the pressure of the air he is breathing rapidly begins to drop, even if the composition of the air in a percentage relationship does not change. During this process decompression occurs. Its influence on the organism depends upon the value of the pressure drop, the rate of the drop, and the period of time during which the man is under increased pressure, as well as on the condition of the organism. The longer he is under increased pressure, the more dangerous decompression is for him.

The essence of decompression disorders consists in an expansion of the free gases which exist in the cavities of our body, and also in a transition of the gases dissolved in the blood and other liquids into the gaseous state. Particularly dangerous in such cases are the inert gases which do not participate in the gas metabolism of the organism, specifically nitrogen, since it occupies 70-80% in volume. The degree of manifestation of decompression disorders can vary -- from hardly noticeable signs to irreversible damage.

Can one avoid decompression disorders?

One can. How does one proceed in order to avoid them is a question whose answer is well known by divers: rising to the surface from a great depth, they make stops of determined duration.

During such a staged transition from high pressure to lesser pressure, no energetic release of gases occurs and one succeeds in avoiding the appearance of gas bubbles in the tissues and fluids of the organism, while the gases dissolved in the blood and other body fluids leave the organism during respiration.

In aviation, cosmonautics, and during experimental "elevations" in the pressure chamber, a somewhat different method of preventing decompression disorders is employed. It is called desaturation. During this process, as the

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result of breathing pure oxygen, nitrogen is washed out of the human organism. This is done before a flight to high altitude or when locking prior to entering open space.

It has been established that one-third of the nitrogen contained in the blood and tissues is eliminated in 15 minutes, while up to two-thirds is eliminated in an hour. For complete elimination of nitrogen about a day is required. As aviation experience shows, a 1-2 hour desaturation is adequate for preventing decompression disorders.

Partial desaturation also occurs when breathing ordinary air under decreased pressure. A change in the atmosphere in the Soyuz spacecraft prior to docking will also make possible partial desaturation of the organisms of the Soviet cosmonauts.

Prior to launch, normal pressure is maintained in the Apollo, but the artificial atmosphere of the cabin consists of 60% oxygen and 40% nitrogen. This is done to decrease the danger of fire. During insertion of the spacecraft into orbit, the oxygen-nitrogen mixture is gradually removed from the cabin and replaced by pure oxygen, but at a pressure of 0.35-0.4 atmospheres. This is explained by a number of concepts, including the necessity of providing the cabin of the Apollo with the necessary reserve of stability.

Several hours prior to landing the spacecraft and prior to replacing the cabin atmosphere, the American astronauts remain in space suits and breathe pure oxygen. This also thus permits them to adapt easily to a decreased pressure.

For transferring to the Soyuz, the American astronauts will first have to create an atmosphere in the locking assembly which is similar to the atmosphere of the Apollo, enter this assembly and close the lock leading to their spacecraft. Then, for approximately 15 minutes they will have to replace this atmosphere with the atmosphere of the Soyuz. Pressure in the locking assembly will be increased to 0.7 atmospheres and pure oxygen will be mixed with nitrogen. After this the astronauts will only have to open the hatch in the locking assembly and enter the orbital compartment of the Soyuz.

If measures were not taken to approximate the atmosphere of the spacecraft, the return of the American astronauts to the Apollo and the transfer of the Soviet cosmonauts to them would be fraught with somewhat great difficulties, for then they would transfer from an atmosphere at high pressure to an atmosphere of low pressure, and this, as we have already mentioned, will entail decompression disorders.

But inasmuch as it has already been agreed that several hours prior to docking the spacecraft pressure in the Soyuz will be lowered to 0.7 atmospheres, a long stay of the astronauts in the locking assembly will not be necessary. And with maintenance of the previous pressure in the Soyuz this will require no less than two hours.

Nearly two years remain until the joint flight of Soyuz and Apollo. Whether or not the parameters of the atmosphere of the spacecraft and the accepted system of transfer will remain is hard to affirm. It is not impossible that certain slight corrections may be introduced.

Why slight? Because when developing spacecraft, the life support systems and other devices and instruments, pressure within their enclosures is taken into account.

In the opinion of the American specialists, an increase in pressure in Apollo of more than 0.4 atmospheres would create problems with the design of windows, hermetically sealed equipment blocks, and various types of insulation, as well as disrupt the normal operation of the safety valves.

In discussing the program of the joint Soviet-American space experiment, the atmosphere of promising manned objects of both countries has also been under discussion. In the future its standardization would take up the problem of adaptation of cosmonauts during transfer from one spacecraft to another. The opinion has been expressed that atmospheric pressure must be 0.6 atmospheres, while its composition must be 40% oxygen and 60% nitrogen.

Such atmospheric parameters have been chosen because a subsequent decrease in pressure will make it necessary to increase the percentage content of oxygen in the spacecraft's atmosphere. This increases the danger of fire.

Additionally, in such an atmosphere preliminary desaturation is not required for the cosmonauts to enter open space.

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